Journal of Engineering and Applied Sciences 10 (8-12): 267-269, 2015
ISSN: 1816-949X

Energy-Saving Setting for Drying Grain with a Heating Element

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Abstract: Proposed energy-saving setting for drying grain, heating elements made in the form of a flat metal plate that can significantly reduce energy costs. This technology made uniform drying of grain in a wide temperature range which is achieved by changing the frequency and voltage converter. The study describes the theory of motion of grain on the helical surface which is the main working body of the high-frequency induction grain drying machine. Prove change the angle of inclination of forming a helix and its polar radius depending on humidity at the moment when driving on the inside of the radiator helicoid microwave drying.

Key words: Grain drying, energy-saving setting, flat metal plates, electrical coil, the frequency converter

INTRODUCTION

Drying of grain during the harvest in wet weather in the northern regions of Kazakhstan has always been an important issue for agriculture. It is one of the most important, energy-intensive and expensive operations with grain that determines the safety and value of the harvested crop, the method of drying determine the quality of the stored grain. It is known that <90% of the grains subject to artificial drying. Up to 80% of the wheat that goes to processing plants or farms, it has a moisture content of 35-40%. For long-term data in the grain with a moisture content above 17% (crude) supplied on average 82.1% of the total. Under such conditions, the wheat grain refers to a volatile storage cultures (Babalis *et al*., 2006). Basic theoretical and experimental research related to the study of the removal of moisture, grain drying using a high-frequency and microwave heating and its application in agriculture and other industries have been conducted by academician A.V. Lykov, G.A. Maximov, G. Pyushnerom, A.A. Vogel, N.V. Knipper, S.V. Nekrutmanom (Babalis *et al*., 2006; Demir *et al*., 2007; Roberts *et al*., 2008). Later these researches were continued and deepened academics I.F. Borodin, I.A. Rogov (Jayashree *et al*., 2010) doctor of technical sciences Vendina S.V. (Hemisatal, 2012) and other scientists.

MATERIALS AND METHODS

We have discussed a method for drying grain and remove moisture is an induction heating which was poorly understood and rarely used due to a significant imperfection of the production technology of the frequency converter of high power (up to several hundred kW) and frequency (up to several hundred kHz). But, at this time the induction heating equipment has received a great development and its application to dryers, compared with conventional methods of heating, more preferably. In the process of induction of grain drying energy is applied directly to the grain, so it is possible to achieve not only high performance but also high efficiency drying. The evaporation process can be carried out quite intensively, even when exposed to temperatures of up to 45-55°C. Thus, there is no heating of the casing of the equipment, so no loss of non-process heat.

Induction heating and equipment used is completely harmless to the environment. After analyzing the above, we adopted a hypothesis about the effectiveness of drying wheat by using induction heaters. Placing them at regular intervals and changing this interval, it is possible to carry out intermittent drying and thermal management. The drying process is accelerated by simultaneously heated by heated air blown grain. The methodology of the study consists of the following tasks:

- Determination of the initial moisture content of grain
- Determining the optimum distance between the plates of the heating system
- Determination optimum thickness induction heaters and enters the layer of grain which is located in the heating installation
- Carrying out the drying process itself
- Determination of the heating temperature of grain
- Determination obtained after induction heating grain moisture
- Control of electricity consumption directly to the drying process

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RESULTS AND DISCUSSION

Also in the experiment, we measured the temperature of the grain of wheat carried out by the method of thermometer KT300 single unbalanced bridge DC (Fig. 1-4).

Experiments were carried out in several stages. The first step was to determine the distance from the surface of the plate toward its thickness d, at which the current density decreases by a factor of e, i.e., by 63.2%, conventionally referred to the penetration depth of the current (Roberts *et al*., 2008). The depth of current penetration determined by Eq. 1:

$$\Delta = \sqrt{\frac{2}{\omega\mu\gamma}}, M \tag{1}$$

Where:

- ω = The $2\pi f$
- f = The current frequency (Hz)
- μ = The magnetic permeability of the wire material in a practical system units (H/m)
- γ = Conductivity material wires

From Eq. 1, equating it to the thickness of the plate is possible to determine the optimum frequency current:

$$f = \frac{1}{\pi d^2 \mu \gamma} \tag{2}$$

With regard to increasing the thickness of the heated plate to a depth of penetration of the current at a constant current in the coil of the energy transferred to the plate increases. The power can be calculated by Eq. 2 (Jayashree *et al*., 2010):

$$P_a = \frac{\pi h}{\gamma}(W_1 l_1)^2 F\left(\frac{d}{\Delta}\right) \text{Вт} \tag{3}$$

Where:

- $W_1 l_1$ = Ampere turns of the coil per unit height of the plate is numerically equal to the magnetic field H
- h = The height of the plate (m)
- $F(d/\Delta)$ = $K(d/\Delta)$ Empirical function where x = 0.75

As a result, the experimental data revealed that with an increasin d/Δ function $F(d/\Delta)$ of increasing, hence, increases and the power delivered to the plate. At a constant current in the same induktore-means increase of the electric efficiency of energy transfer in the plate.

As a result, the 1st phase of the experimental studies found that the efficiency is sufficiently high and practically does not depend on the frequency of the current already and is determined by the ratio between the

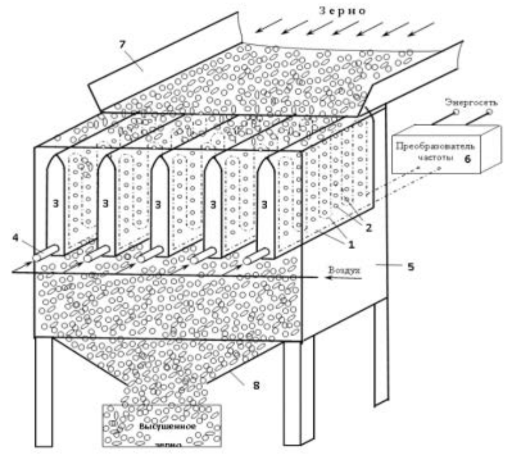

Fig. 1: The experimental setup

Fig. 2: Model the experimental setup

Fig. 3: The 3D model

Fig. 4: Temperature measurement wheat

Table 1: The results of the experiments

t	w	a10	a20	a40	a60	a100	a200	a400
10	2	7,142,185	6,841,155	6,540,125	6,364,034	6,142,185	5,841,155	5,540,125
20	6	6,762,629	6,461,599	6,160,569	5,984,477	5,762,629	5,461,599	5,160,569
40	10	6,427,252	6,126,222	5,825,192	56,491	5,427,252	5,126,222	4,825,192
60	14	6,128,765	5,827,735	5,526,705	5,350,613	5,128,765	4,827,735	4,526,705
100	18	5,861,398	5,560,368	5,259,338	5,083,247	4,861,398	4,560,368	4,259,338
150	22	5,620,527	5,319,497	5,018,467	4,842,376	4,620,527	4,319,497	4,018,467
200	26	5,402,398	5,101,368	4,800,338	4,624,247	4,402,398	4,101,368	3,800,338

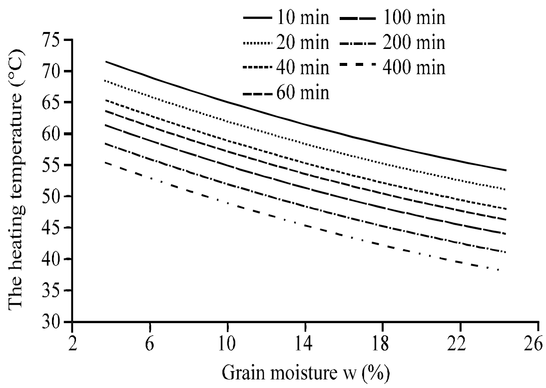

Fig. 5: Show the drying investigated at different grain moisture

conductivity of the material to be heated and copper plates from which the inductor is made. At high frequency ensures a high efficiency of energy transmission in the heated body.

The results of the experiments were the curves which show the drying investigated at different grain moisture (Table 1).

After analyzing the above, we adopted a hypothesis about the effectiveness of drying wheat by using induction heaters. Placing them at regular intervals and changing this interval, it is possible to carry out intermittent drying and thermal management. The drying process is accelerated by simultaneously heated by heated air blown grain (Fig. 5).

CONCLUSION

The main advantage of the dryer by the induction heating is to reduce the heating time, thereby saving energy and speeding up the process of drying the grain. Saving the electricity is due to the fact that the heating element is disposed within the drying chamber, heat is directly transmitted grain which implies a reduction of costs. Drying method using induction heating-using inductive heaters has a smaller specific energy consumption. Equipment used for this is simple and high performance. Heating temperature of the grain should not exceed 55°C. Drying grain induction heating can improve the quality of drying and design perspective creates a more advanced designs dryers.

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